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Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

MATBAL6: A COMPUTER PROGRAM FOR MATERIAL BALANCE DATA ADJUSTMENT - A USER'S GUIDE

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September 1991

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MATBAL6

A COMPUTER PROGRAM FOR MATERIAL BALANCE DATA ADJUSTMENT

USER'S GUIDE

J. Leung

October, 1991

CAMP

COMPUTER AIDED MINERAL PROCESSING

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1. INTRODUCTION

Material balance adjustment is one of the most common calculations performed in mineral process engineering. Plant metallurgists need to calculate production inventories and to assess process efficiencies; research engineers need to smooth process data prior to undertaking modelling studies; design engineers may use it for process retrofitting as a substitute to predictive mass balance programs. MATBAL has become a quasi-standard in the mineral processing industry and needs little further introduction. Initially published in 1970 by R.Wiegel et al.(1), the algorithm for the general least-squares solution of the coherent material balance problem in complex flowsheets using the Lagrange multipliers technique has been successfully upgraded and released in several versions by CANMET(2,3,4,5). Top rating was given to MATBAL in published comparative studies. On-line interfacing to X-Ray analyzers and progress towards a powerful combination of expert system technology has also been reported(6).

MATBAL features a flowsheet drawing option and automatic flowsheet analysis including generation of mass conservation equations and node combination. Numerical data is entered using full screen colour editors. The program calculates solid, liquid, metal or mineral flowrates; adjusted assays and recoveries; and estimates the confidence interval of calculated flowrates. The latest improvements in version 6 of MATBAL(7), provide more flexibility and capability by giving the user the option of defining new unit symbols, screen colours, font size, cursor speeds, drawing board dimensions, video mode, plotter configurations etc. The program also includes new features to check data consistency, to display results during each iteration, to modify convergence criteria during the execution, to print results either grouped by streams or by components and to view results for selected streams and units on the flowsheet. Informative or error messages are also displayed on the screen during execution.

MATBAL is especially designed to calculate flowrates of one phase (pulp, solid or liquid) travelling through a circuit when assays of one or several components of that phase are measured (e.g. chemical assays of solids in a flotation plant).

2. GETTING STARTED

The README.DOC file on the UTILITY/SAMPLE RUN disk contains information for quick starting-up or any new or revised material that could not be included in this user's guide. The user should read it before starting the program installation.

2.1 Hardware Requirements

- IBM-PC, PC XT, PC AT, 386 or compatibles operating under MS-DOS (version 3.0 or higher)
- Hard disk drive (10 MB or more)
- 5.25 inch (360 KB, option 1.2 MB) or 3.5 inch (740 KB or 1.4 MB) diskette drive
- 640 KB of RAM memory or more
- IBM Colour Graphic Adapter (CGA) or IBM Enhanced Graphic Adapter (EGA) or Video Graphic Array (VGA) and compatible monochrome or colour monitor
- IBM compatible printer like EPSON, PANASONIC etc.

The following equipment is optional :

- Math coprocessor
- Epson HI-80 plotter/ HP 7475A plotter (other plotters may be adapted, see section 2.3.5.1)

2.2 Software Requirements

Unless otherwise specified, the MATBAL program is shipped in four 5 1/4 inch diskettes: diskette 1, EXECUTABLE 1; diskette 2, EXECUTABLE 2; diskette 3, INSTALL/FONT; diskette 4, UTILITY/SAMPLE RUN.

2.2.1 Files on diskettes

Diskette number	Title	Files
1	EXECUTABLE 1	BIOS.EXE FLODR.EXE MATEDI6.EXE MATIN.EXE
2	EXECUTABLE 2	MATBAL6.EXE MATVIE6.EXE
3	INSTALL/FONT	CPWRIT.CMP FASTDUMP.COM FASTDUMP.DOC EPPLOT.EXE HPPLOT.EXE HPPLOT.FOR INSTALL.DAT INSTALL.EXE INSTALL.SCN COURB.FON HELVB.FON MODERN.FON ROMAN.FON SCRIPT.FON TMSRB.FON LPRINT.OBJ PLOTTER.BAT PLOTTER.DAT SCREEN.DAT SEC.@01 SEC.@02 SEC.@03
4	UTILITY/SAMPLE RUN	CONVER.DAT CONVER.EXE CONVER.SCN README.DOC FPAGE.MB1 FPAGE.MBL MATBAL.DAT MATBAL.PRT MATBAL.ANS MATBAL.STS MATBAL.OUT MATBAL.TXT UNITS.DAT WINVAL.DAT

2.2.2 Operating system and system configuration

MS-DOS Version 3.00 or higher. The ANSI driver system must be installed in CONFIG.SYS as follows (see your DOS operating system for more information (8)) :

```
DEVICE=C:\DOS\ANSI.SYS  (or equivalent)
```

The following instructions must be added to the file CONFIG.SYS (8).

```
FILES = 20
BUFFERS = 20
```

2.3 Program Installation

Before transferring all the software provided in the diskettes to your hard disk, it is recommended that the PC environment be set up for MATBAL. The procedures are as follows :

2.3.1 Setting up a subdirectory

Return system to root directory (C> or D>), and create a directory called MATBAL6. To do this, type

```
CD\                 <CR>[1]
MD\MATBAL6          <CR>
```

A directory called MATBAL6 will be created. You can use any legal name other than MATBAL6. All MATBAL6 software should be copied into this directory.

2.3.2 Transferring files to subdirectory

To do this, load MATBAL6 diskettes one at a time in drive A and type

```
CD\MATBAL6          <CR>
COPY A:*.*          <CR>
```

[1] <CR> means hit carriage return

NOTE:

The following sections (2.3.3 to 2.3.5) contain the information on how to customize the plotter configuration, the text and graphic operating modes used in the program. It is recommended that the first time user read them very carefully before making any changes.

2.3.3 Selection of colours

All the colour used in MATBAL text mode can be changed with the program INSTALL.EXE. A display showing all the possible colours with their numeric codes can be viewed in the INSTALL program. To choose the colour used by DOS, the background and foreground colour codes have to be specified. This is because the colours used by DOS are fixed using the ANSI driver technique instead of the ROM BIOS technique. Further information on this subject may be found in the literature (9,10,11,12).

In graphic mode (used to draw the flowsheet) the colours are specified in the file SCREEN.DAT. The structure and the procedure to modify the file SCREEN.DAT is explained in the next section.

2.3.4 Modification of drawing board options

In MATBAL, flowsheet drawing is done in graphic mode where the computer screen is divided into pixels instead of lines and columns. The area for flowsheet drawing is called drawing board. Some options controlling the drawing board can be changed by the user in the file SCREEN.DAT. The first part of this file contains the option values and the second part a small help text describing them. The options in this file may be modified with any text editor. Following is a description of these options.

2.3.4.1 Computer screen dimensions

The dimensions of the computer screen are needed in order to draw circles properly. The default values are 245 millimeters for the width and 183 millimeters for the height.

2.3.4.2 Starting point of drawing board

The drawing board is delimited by a box and the starting point is defined by the XY-axis of the upper left corner of the drawing area (the origin of the XY-axis is situated at the top left corner of the screen). This point can be selected by the user such that the line or lines above the drawing board can be reserved for message display.

2.3.4.3 Cursor movement

To move the cursor on the screen, the user can select different combinations of keys to control the step size. The step size is defined in file SCREEN.DAT by "minimum" and "maximum" step values in millimeters.

1. Arrow keys only: activates the "maximum" step size
2. <Shift> + arrow keys: activates the "minimum" step size
3. <Ctrl> + arrow keys: activates a step twice the "maximum" step size and is available only for left right motion

Note:

1. **The state of the "NumLock" key is assumed "OFF". If the "NumLock" key is "ON", options 1 and 2 are reversed.**

2. **The additional arrow keys found on an enhanced keyboard (situated outside the numeric keypad) cannot activate the "minimum" step size.**

2.3.4.4 Drawing board colours

The colours on the drawing board can be selected by the user. The numerical codes of the available colours are given in the help text in the file SCREEN.DAT. More information on colour codes can be found in Microsoft FORTRAN, Advanced Topics (13).

NOTE:

To plot a flowsheet using "H" key on the drawing board, make sure the numerical colour codes used in the flowsheet is equal or less than the number of pens available in the plotter (e.g. for a plotter with 6 pens, the colour codes for title, streams, units or text of a flowsheet should be 6 or less; otherwise, the flowsheet will not be plotted properly).

2.3.4.5 Manual or automatic selection of video mode

The video mode (CGA,EGA or VGA) can be selected either automatically by the program according to the equipment installed or manually by the user. In the manual option the user must ensure that the hardware is compatible with the video mode selected. MATBAL is initially set to have the video mode selected automatically by the program.

2.3.4.6 Font selection

Two fonts are used on the drawing board: one for the title, stream and unit numbers; the other for the text used in the unit diagrams. Since unit diagrams are drawn with the UDRAW program, consistency of the font selection must be borne in mind.

The fonts available in the program are listed in the help text in SCREEN.DAT and are originally supplied by the Microsoft Fortran Compiler (13).

Note:

For users with limited memory size, only "modern" font can be used in MATBAL. This is also the only font that is similar to the font available in most plotters.

2.3.5 Selection of the plotter

This version of MATBAL is compatible with two plotters : the EPSON HI-80 (14) and the HEWLETT-PACKARD (HP) 7475A (15). The selection of the plotter as well as the definition of the communication parameters are entered on the last two display screens in the INSTALL program after selecting the colours used in the text mode (section 2.3.3) on the first two screens. By default, HP-7475A has been selected and the communication parameters are as follows :

```
Communication port = COM1
Baud rate          = 9600
Parity             = Even
Data bits          = 7
Stop bits          = 1
```

For further information on communication parameters, the user should refer to the reference guide of the DOS operating system (8).

For user with other types of plotter, a different plotter driver is required. Appendix B explains how to write one and the source code of the HP-7475A driver, called HPPLOT.FOR, is supplied with the program as an example.

2.4 Program Execution

Since the MATBAL program requires at least 570 KB of memory core, the user must ensure, before running MATBAL6, that no large programs are resident in memory. Otherwise, messages such as " PROGRAM TOO BIG TO FIT IN MEMORY " and "ALLOCATE - HEAP SPACE LIMIT EXCEEDED" will be issued by the system, or some features in the flowsheet drawing board (e.g. displays of help text or stream connection matrix) will not function properly.

The MATBAL program consists of three drivers which are to be executed sequentially. They are:

MATEDI6: to create or modify process flowsheet and data; and to produce hard copy of input data

MATBAL6: to calculate material balance and scroll/print results either grouped in components or in streams

MATVIE6: to view results of macroscopic stream flowrates or results of individual streams and units on the flowsheet

To execute them, type

MATEDI6 **<CR>**

or

MATBAL6 **<CR>**

or

MATVIE6 **<CR>**

NOTE:

It is recommended that the first time user run through these three drivers using the sample run provided in MATBAL.DAT before customizing the text and grahpic operating modes with the INSTALL program.

3. PROGRAM STRUCTURE

As mentioned in section 2.4, the MATBAL program consists of three drivers: **MATEDI6** for flowsheet drawing and data entry; **MATBAL6** for material balance calculation and results scrolling and **MATVIE6** for result viewing via the flowsheet. The relationship among the drivers is displayed in figure 1 and the general structures of each driver are displayed in figures 2,3 and 4 respectively.

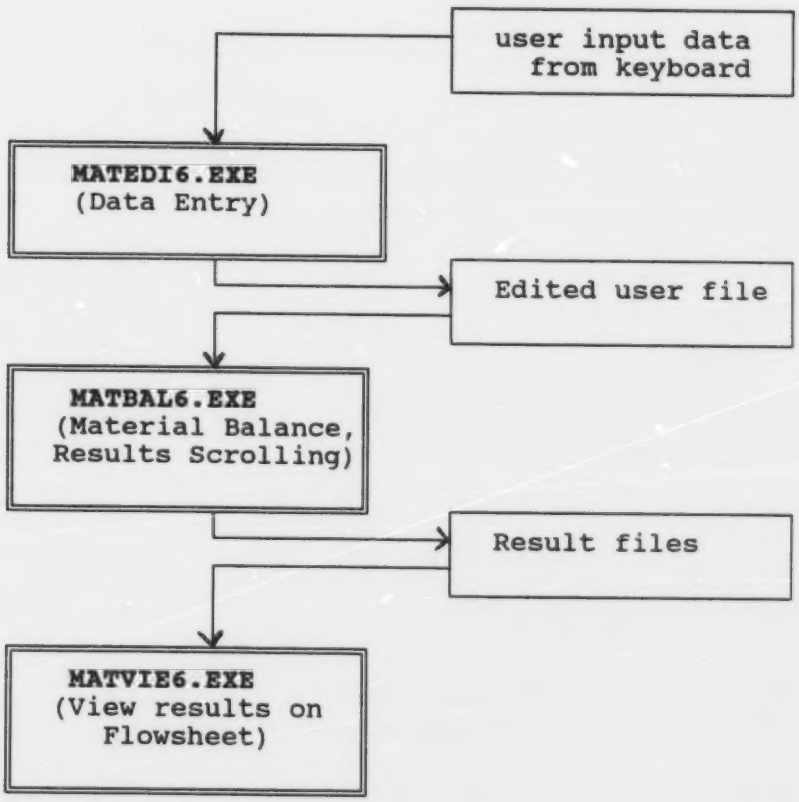


Figure 1 : Drivers relationship

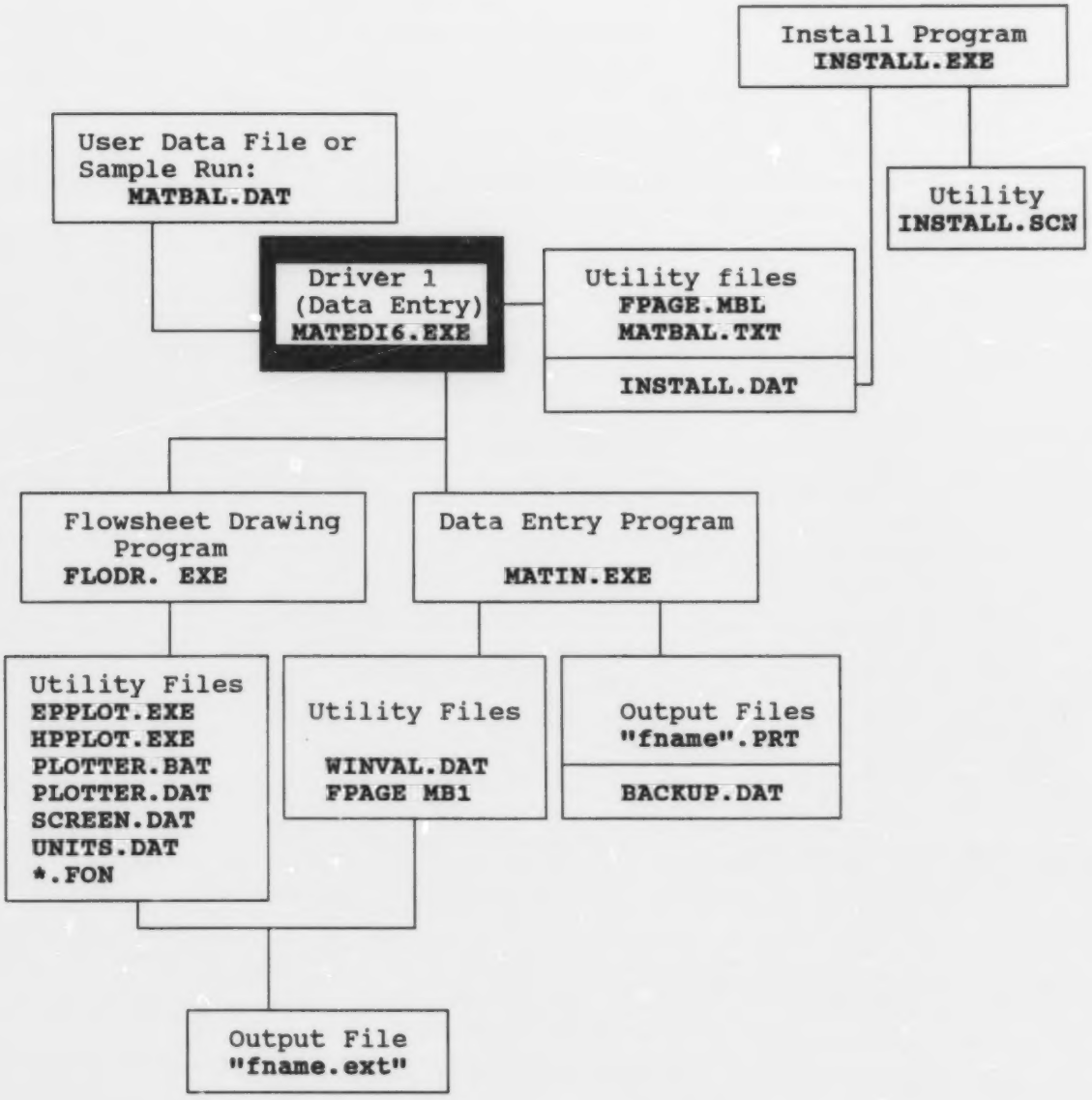


Figure 2 : Structure of MATEDI6

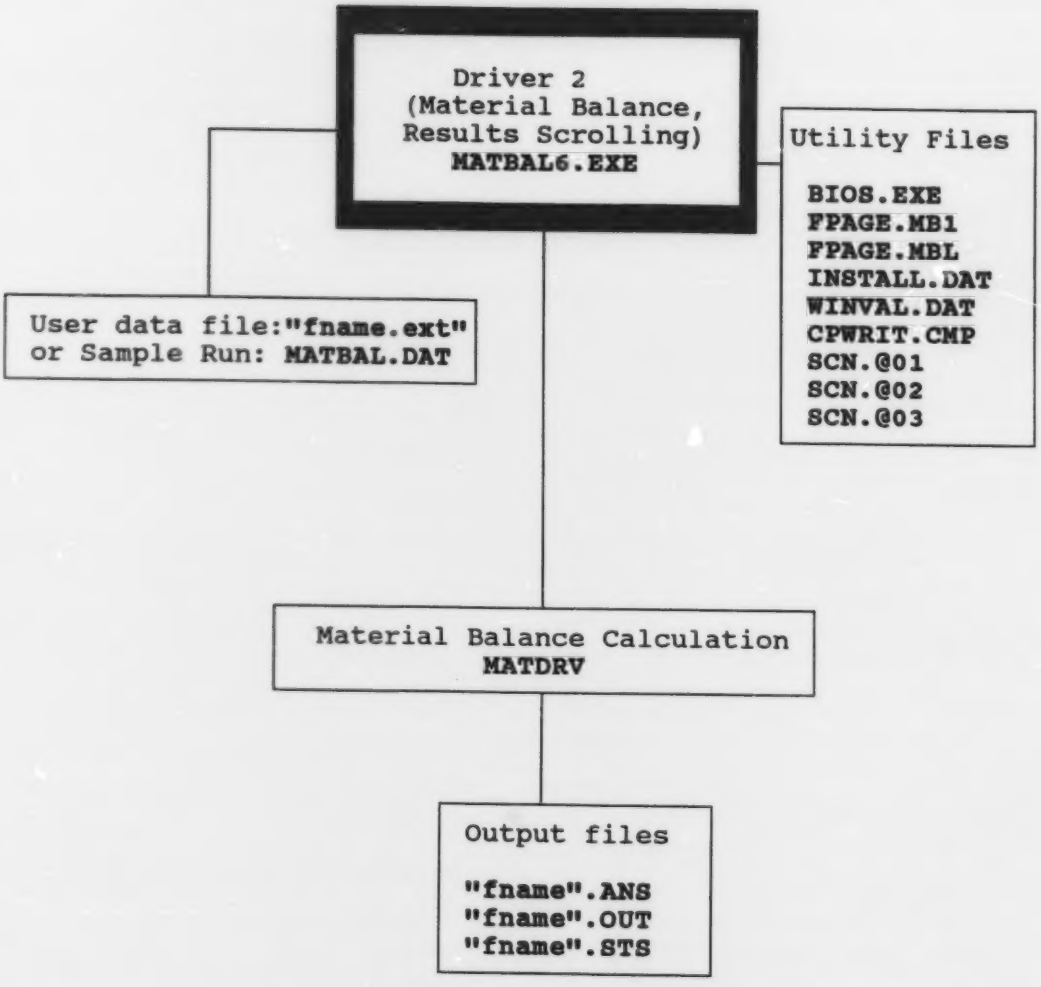


Figure 3 : Structure of MATBAL6

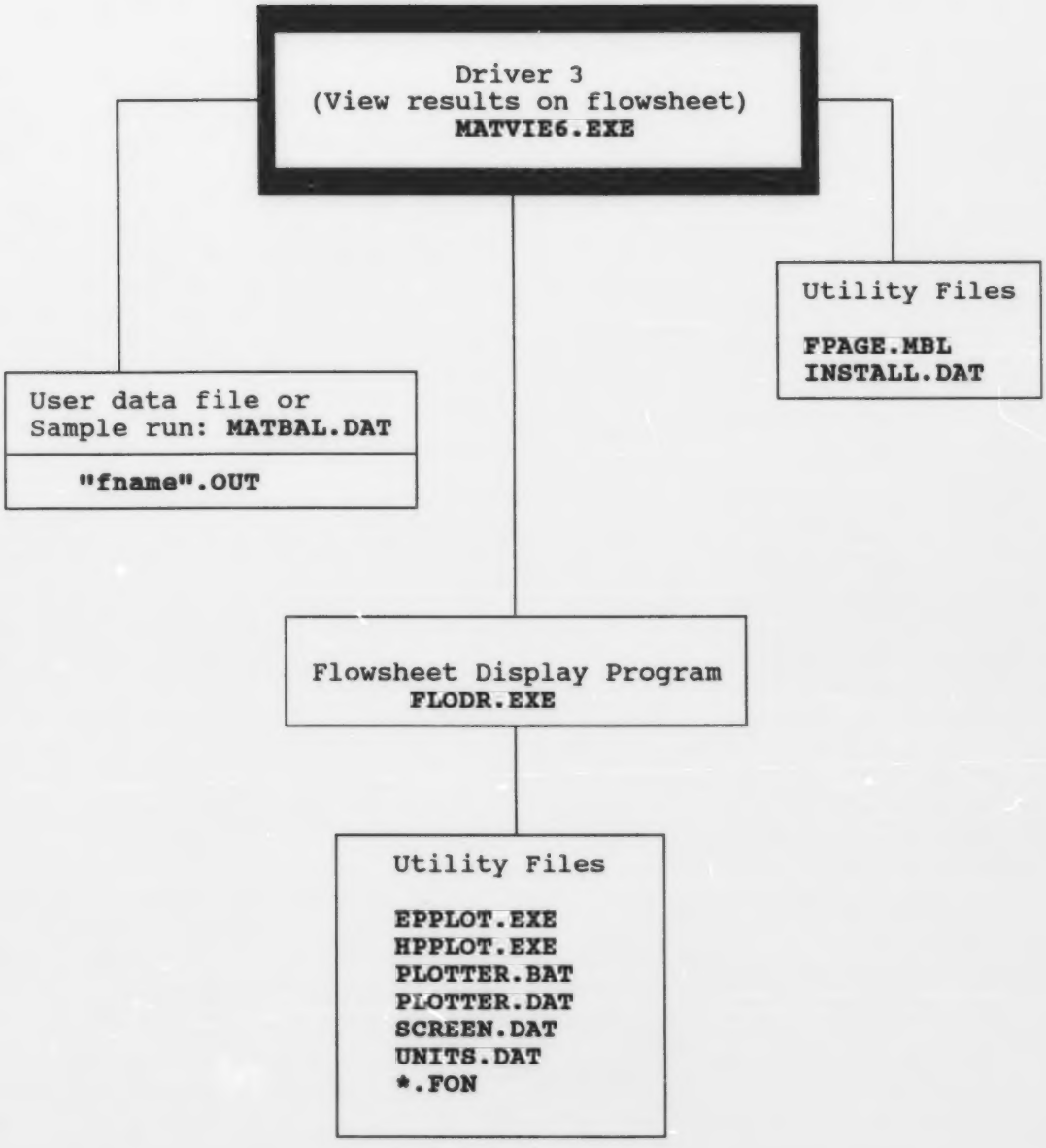


Figure 4 : Structure of MATVIE6

3.1 Stand-alone Utility Programs

CONVER : program to convert flowsheet data created by MATBAL5 to the format used in MATBAL6; without the conversion, MATBAL5 flowsheet will not be displayed properly in MATBAL6 and this may cause different stream connection matrix for the same flowsheet; required files are: CONVER.SCN and CONVER.DAT

NOTE:

Make sure all connecting (input or output) streams of a unit are "touching" or within one or two millimeters of the boundaries of that unit. Otherwise, they will not be "seen" by the program as connecting.

FASTDUMP: to print a flowsheet on HP LaserJet printers with the "Print Scrn" key; type FASTDUMP at the DOS prompt before executing the MATBAL program; refer to FASTDUMP.DOC for further information

INSTALL : program to define the type of monitor, plotter configuration, display colours in the text mode and DOS (see sections 2.3.3 and 2.3.5); required files are: INSTALL.SCN and INSTALL.DAT;
(INSTALL.SCN contains screen display and INSTALL.DAT contains the colour codes to be read in by MATEDI6, MATBAL6 and MATVIE6)

UDRAW : program to create, delete or modify unit symbols used in the flowsheet drawing; units symbols are stored in UNITS.DAT that is to be retrieved by MATEDI6 and MATVIE6; required files such as HELP.UDR, DISPLAY.UDR, *.FON and SCREEN.DAT are provided in seperate diskettes (for more information, refer to its user's guide)

3.2 Drivers and Main Routines

The main routines used in each driver are described as follows :

a) **Driver MATEDI6 and its main routines**

MATEDI6 : main driver to call FLODR for flowsheet drawing and MATIN for data entry.
(files are stored in MATEDI6.FOR)

FLODR : program used as a sub-driver to call other subroutines to draw flowsheet and derive stream connection matrix (SCM).
(files are stored in FLODR1.FOR, FLODR2.FOR, UTIL1.FOR and UTIL.FOR)

MATIN : program used as a sub-driver to call other subroutines to enter the values of assays, flowrates, program options etc..
(files are stored in MATIN.FOR, MASSAY.FOR, MSTREAM.FOR, MFOPT.FOR, MUTIL.FOR and NODE.FOR)

b) **Driver MATBAL6 and its main routines**

MATBAL6 : main driver to call Subroutine MATDRV for material balance calculation.
(files are stored in MATBAL6.FOR)

MATDRV : routine used as a sub-driver to call other subroutines for material balance calculation and final results scrolling.
(files are stored in MATDRV.FOR, SOLV.FOR and MATOUT.FOR)

c) **Driver MATVIE6 and its main routines**

MATVIE6 : main driver to call FLODR to view results of macroscopic stream flowrates or results of individual streams and units on the flowsheet.
(files are stored in MATVIE6.FOR)

NOTE:

Although the flowsheet drawing board is also available in MATVIE6, it should only be used for result display and not for flowsheet creation purpose.

3.3 Utility Files

The following files contain operating data, help text and screen display layouts. Except the file SCREEN.DAT, they **must not** be modified or deleted by the user.

MATBAL.TXT : help text for MATBAL

BIOS.EXE : internal operation file

FPAGE.MBL : contains screen display of the main menu and messages prompted by the main menu

FPAGE.MB1 : contains screen displays used in data entry

SCREEN.DAT : operating data for the drawing board options such as screen dimensions in millimeters, cursor speed, colour codes, font types, video modes etc.. (section

2.3.4 and its subsections explain how to modify these parameters)

SEC.@01 : file used by the security system

SEC.@02 : file used by the security system

SEC.@03 : file used by the security system

UNITS.DAT : contains predrawn unit diagrams. This file is created by a separate program called UDRAW which allows the user to create his/her own unit diagrams. (UDRAW is included with the MATBAL program)

WINVAL.DAT : contains the information of the data entry windows (e.g. X,Y-positions of the windows, no. of windows per screen etc...) in each screen

*.FON : files containing the fonts available for the drawing board

NOTE:

For systems with limited DOS addressable memory, the flowsheet can only be displayed using "Modern" font.

3.4 Output Files

The following files are created by MATBAL :

BACKUP.DAT: contains data entered by the user in MATEDI6. This file is automatically created and the data are saved after each entry of the data categories (see section 4.1.2). It is extremely useful in case of a power failure that could occur during data entry. However, this file does not include the flowsheet and the user can use any word processor to combine the flowsheet and the data in one file.

"fname".PRT : contains data entered by the user and information derived by MATEDI6 such as mass equations, assays balanced around each node and the node status (whether normal or non-normal node). This file is automatically created when input data are saved in a user named file "fname" (an extension PRT is automatically assigned by the program). The input data can be printed if required.

"fname".ANS : contains **complete** results of material balance and can be scrolled on the screen. The results include all the output options chosen by the user and the final

results are grouped by components instead of by streams.

"fname".STS : contains **final** results of material balance grouped by streams and can be scrolled on the screen.

"fname".OUT : contains results of macroscopic stream flowrates and results of individual streams and units. This file is retrieved in MATVIE6 in order to view the results on the flowsheet. It is automatically created in MATBAL6 when the user saves the results in "fname".ANS and "fname".STS.

NOTE:

"fname" is a generic file name chosen by the user and the extensions such as PRT, ANS, STS and OUT are assigned by the program.

3.5 Plotter Files

The batch file PLOTTER.BAT and the data file PLOTTER.DAT are used to produce a hard copy of the flowsheet on one of the two plotters (EPSON HI-80 and HP-7475A). The files EPPLOT.EXE and HPPLOT.EXE are the drivers developed for these two plotters.

PLOTTER.DAT : Data file that contains flowsheet data in an ASCII format for an EPSON HI-80 plotter. It can be translated to other types of plotters.

PLOTTER.BAT : Batch file that defines the communication parameters, executes the driver and sends the instructions to the plotter.

EPPLOT.EXE : Driver that sends the flowsheet data to an EPSON HI-80 plotter.

HPPLOT.EXE : Driver that translates the flowsheet data and sends them to a HP-7475A plotter.

4. PROGRAM OPERATION

The three drivers used in the MATBAL program are menu driven with keyboard help at every processing stage.

4.1 MATEDI6: Flowsheet and Data Entry

The main menu of MATEDI6 is displayed (as below) as soon as MATEDI6 is executed:

```
                    M A T E D I 6

   Full screen data editor of material balance program MATBAL6

                        1 9 9 0
                     CAMP PROJECT
                     CANMET/EMR
```

```
TABLE -1- : MENU OPTIONS

F1  Help Text
F2  Retrieve Data From File
F3  View/Modify Flowsheet
F4  View/Modify Data
F5  New Flowsheet Entry (optional)
F6  New Data Entry
F7  Save Flowsheet/data In File
F8  Shell To DOS
F9  Quit "MATEDI6"
```

```
TABLE 2- MESSAGES
```

```
TABLE-3- HELP
ARROWS   : Move Highlight Bar
"F" keys: Menu Options
ENTER    : Option Selected
ESC      : Return To Table-1
```

Note:

1. **Flowsheet drawing is done with option F3 or F5. It is also possible to create your data directly without a flowsheet i.e. using options F4 or F6.**

2. **Make sure the flowsheet or data are saved using option F7 as soon as they are modified or created. A flowsheet can be drawn in stages, however, it must be saved at each stage. Flowsheet or data that are not saved will be lost. To view the data via option F4, make sure the file retrieved contains the data you want.**

3. **When retrieving a file, the user must make sure that the file name is correct. The data file created and saved in MATEDI6 will be used in the other two drivers MATBAL6 and MATVIE6.**

4.1.1 Flowsheet drawing

The circuit flowsheet can either be :

a) retrieved and modified by selecting option F3
b) newly created by selecting option F5

4.1.1.1 Design menu

The flowsheet design menu contains a definition of all the pre-programmed keys used on the drawing board. It is displayed before entering the drawing board and can be consulted any time with the "?" key. From this menu, to return to the main menu, press "ESC" key; to go to the flowsheet drawing board, press the "PgDn" key or to get help text, press "F1" key. The pre-programmed keys in the drawing menu are :

```
FLOWSHEET DESIGN MENU
---------------------


Key              Function
---              --------
 A          Alter Flowsheet Creation Options
 C          Change Resolution high/medium (CGA)
 D          Delete Unit or Stream
 G          Display Grid
 H          Hard Copy on Plotter
 L          Write Labels
              S        to start
              RETURN   to end line of text
              Backspace  to erase last character
              T        to exit label mode
 M          View Stream Connection Matrix
 O          Show Results
 P          Paint All Units
 R          Redraw Flowsheet
 S          Start Stream (max. 40 streams)
 T          Terminate Stream
 U          Place Unit (max. 36 units)
< >         Space Bar For Stream Corner
ESC         Exit to Main Menu

F1: Help text;   ESC: Exit to main menu;  PgDn: Flowsheet
```

Note:

1. **To print the flowsheet while in the drawing mode, either press "H" for hard copy from plotter or "PrtSc" for hard copy from an ordinary printer (make sure the plotter or printer are turned on before pressing the key).**

2. **For HP LaserJet plotter, make sure to run "FASTDUMP" command at the DOS prompt before executing the MATBAL program.**

4.1.1.2 Unit diagram

Each unit diagram has been predrawn by a separate program called UDRAW, a stand-alone program which is stored in a separate diskette provided to the user. Its symbol and 3-character unit code which is **case sensitive** are stored in a file called UNITS.DAT (used by MATEDI6 and MATVIE6). Each unit diagram is retrieved during flowsheet drawing by giving the appropriate 3-character unit code or 4-character code with the first 3 characters for unit code and the 4th for unit rotation :

"blank"	:	for no rotation
"+"	:	for 90 degrees clockwise rotation
"-"	:	for 90 degrees counter-clockwise rotation
"*"	:	for mirror image

The list of symbols supplied with the program is as follows:

Symbol	Code	Description	Symbol	Code	Description
	RML	Rod mill		FLO	Flotation cell
	BML	Ball mill		HYC	Hydrocyclone
	MIX	Sump Box		BOX	Global Symbol
	SEP	Separator		COL	Column Flotatior

Note:

These symbols are for illustration purpose only; MATBAL does not recognize specific unit models but implements mass conservation equations. A maximum of 8 streams may be connected to any node.

4.1.1.3 Unit scale/auto numbering

Unit scale (1 - 100%) is used to scale unit diagrams. The reference scale is 100% and corresponds to the full unit size used in UDRAW. This unit scale factor may be changed at any time on the drawing board by pressing the letter "A".

Numbering of units and streams can be done in two ways :

a) automatically by the program
b) manually by the user

NOTE:

If b) is chosen, then the numbers must be consecutive without gaps starting at 1.

Job title, unit scale and numbering mode (automatically or manually) options are selected when entering the flowsheet creation mode as follows:

```
FLOWSHEET CREATE OPTION
-----------------------

 TITLE OF FLOWSHEET (MAX.=38 CH.) :

 UNIT SCALE (1 TO 100%) :

 UNIT/STREAM AUTO NUMBERING (Y/N) ?

  Note:   Unit Scale is used to size unit diagrams
          created in a separate program UDRAW.
          100% corresponds to the full unit size
          used in UDRAW


Arrows: Cursor movement;  PgDn: Flowsheet;  ESC: Exit
```

4.1.1.4 Drawing units

It is recommended to draw the units first before connecting streams. To draw a unit on the screen, the following steps must be taken :

1. Move the cursor to the desired location inside the drawing window. Three different combinations of keys can be used to move the cursor :

   a. arrow keys alone : activates the maximum step size
   b. <Shift> + arrow keys: activates the minumum step size
   c. <Ctrl> + arrow keys : activates a step twice the maximum step size and is available only for left right motion

   NOTE:

   1. **The state of the "NumLock" key is assumed "OFF". If the "NumLock" key is "ON", options a and b are to be reversed.**

   2. **The additional arrow keys found on an enhanced keyboard (situated outside the numeric keypad) cannot activate the minimum step size.**

2. Press "U" (for unit) on the keyboard

3. Enter the 3 or 4 character unit code (see 4.1.1.2) and the desired unit with the right unit size will appear on the screen

4. Enter the unit number if you choose manual numbering in 4.1.1.3

5. By default, the unit number will be drawn from the center of the unit if you press the space bar (< >) without moving the cursor; or you may move the cursor to any desired location and press the space bar.

6. Go to step 1 to draw another unit

Note:

The variable size limitations of MATBAL given in Section 5 should always be kept in mind. The maximum numbers of normal and non-normal nodes must satisfy the following criteria:

a) the sum of normal and non-normal nodes <= 36
b) number of normal nodes <= 25
c) number of non-normal nodes <= 25

(A normal node is a node for which all assays must balance; whereas a non-normal node is any node that is not normal.)

4.1.1.5 Drawing streams

To connect the units with streams, use the following steps :

1. Move the cursor to the stream starting point and press "S" to activate stream drawing option

2. If stream corners (elbows) are required, move the cursor to the desired location and press the space bar (< >)

3. Press "T" to terminate stream drawing option and an arrow is automatically displayed. ("T" has to be entered to terminate a stream before other keys, except "?" key, can be activated)

4. Enter the stream number for manually numbering as described in 4.1.1.4

5. Go to step 1 to draw another stream

4.1.1.6 Adding explicative notes

To add explicative notes to the flowsheet, the user must :

1. Press <L> to enter "LABEL MODE". The message "LABEL MODE" is displayed on the upper right corner of the drawing board.

2. Move the cursor to the starting position and press <S>. The starting position is the upper left corner of the character string.

3. Enter the text on the keyboard and press <RETURN> to terminate this line of text.

4. Repeat steps 2 and 3 to enter other lines of text.

5. Press <T> to terminate "LABEL MODE". The message "LABEL MODE" will disappear.

4.1.1.7 Stream connection matrix (SCM)

The Stream connection matrix (SCM), which lists units connected by each stream, is calculated automatically from the flowsheet on the drawing board (option F5 in section 4.1). It can always be viewed by pressing "M" key. The SCM will be passed to the data entry section for automatic flowsheet analysis (section 4.1.2.3) and generation of mass balance equations. However, if the flowsheet circuit is complicated, the user may choose not to draw the flowsheet and instead enter the SCM in the data entry section (option F6).

An example of SCM is shown as follows :

STREAM-INDEX	STREAM-NUMBER	FROM UNIT	TO UNIT
1	1	0	1
2	2	1	2
3	3	2	0
4	4	2	1

PgUp/PgDn : Page scroll; ESC : Exit

Note: Unit zero refers to origin or destination outside the circuit, i.e. feed or product stock pile.

4.1.2 Data Entry

Circuit data can either be :

a) retrieved and modified by selecting option F4 (section 4.1)
b) newly created by selecting option F6 (section 4.1)

Input is done with the aid of a full screen editor. The description of each variable is displayed whenever possible on the screen and the function of the keyboard action keys are either displayed at the footnote or could be displayed by pressing "?" key (see 4.1.2.4). Most data are in "F12.4" format which should cover most of the data range. If larger numbers are to be used, they must be scaled down to a maximum of 9,999,999.9999.

An example of a data entry screen is shown as follows (single-lined boxes represent the data entry windows) :

ASSAY VALUES — MATBAL6/CANMET PAGE 4

Assay Type	Stream 9	Stream 10	Stream 11	Stream 12
Au(oz/t)	.3240	.2020	.0340	.0000
Ag(oz/t)	1.7200	1.7800	.1900	.8800
%Cu	2.0100	1.5400	.1900	.8900
%Zn	37.0000	46.2000	2.6000	3.0000
%Fe	13.7000	6.8000	14.4000	26.4000

**** REMINDER: 1 Assay value per Assay Type per Stream ****
?: Help; Esc: Exit data entry; Pg/Up/Dn: Page scroll

Input Data are divided in 5 main categories :

1. Job title/ Stream Connection Matrix
2. Assays and error model
3. Stream names, mass equations, assays that balance around a node and node status
4. Measured flowrates or approximation of flowrates
5. Program options e.g. assay types selection, no. of iterations, convergence criteria, Monte Carlo simulations etc.

4.1.2.1 Data creation mode

The following screen is displayed when "data creation mode" (option F6) is entered:

```
DATA ARE TO BE ENTERED IN THE FOLLOWING ORDER :

 0.  TITLE/ STREAM CONNECTION MATRIX

 1.  ASSAYS AND ERROR MODEL

 2.  STREAMS AND NODE STATUS

 3.  FLOWRATES

 4.  PROGRAM OPTIONS

          PRESS ANY KEY TO CONTINUE
```

Note:

1. Category 0 will appear only when no flowsheet exists. After data are entered in the above order, the program automatically goes into Retrieve/Modify mode.

2. Data are automatically saved in file BACKUP.DAT after the entry in each category. In case of power failure, the user can retrieve the data from this file (see section 3.4).

3. Measured or estimated flowrates may become crucial in problems where several equations are "poor" in information, e.g. little or no separation of constituents, poor data redundancy or islands of poor information in otherwise normal problems. Measured flowrates with good accuracy in one or two branches will often remove the indeterminate condition of the problem.

4.1.2.2 Data retrieve/modify mode

The following screen is displayed, when "retrieve/modify mode" (option F4) is entered :

```
Options for Data File Retrieval
-------------------------------

    1 .   Retrieve all data as saved in FNAME.DAT
          including flowsheet, SCM and node status

    2 .   Retrieve all data as saved in FNAME.DAT
          but recalculate node status from saved
          SCM or flowsheet


                Enter 1 or 2 :

                ENTER to continue
```

Option 1 : to retrieve data as previously saved. This includes the mass equations, nodes status or assays retained for balance that might have been **modified** by the user.

Option 2 : to retrieve data and **initiate the automatic flowsheet analysis** (see section 4.1.2.3) which generates the mass equations from the Stream Connection Matrix (SCM) and defines the status of each node according to the assays given in each stream.

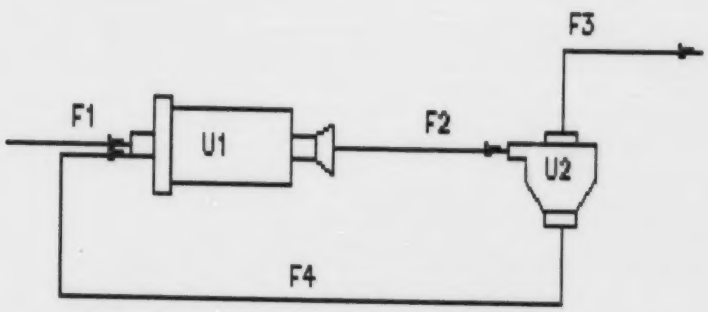
A data review menu is displayed for both options. The user may enter any category to view or modify the data.

```
FOLLOWING DATA HAVE BEEN ENTERED
--------------------------------

 0.  TITLE/ STREAM CONNECTION MATRIX

 1.  ASSAYS AND ERROR MODEL

 2.  STREAMS AND NODE STATUS

 3.  FLOWRATES

 4.  PROGRAM OPTIONS


Review/modify data (option+ENTER) :
ESC: to main menu
```

4.1.2.3 Automatic flowsheet analysis

Once the stream connection matrix of a circuit is available from the flowsheet drawing or through data entry, the flowsheet analysis will be performed by the MATBAL program. This includes automatic generation of mass conservation equations; node types definition and automatic node combination (i.e., if two nodes are connected by an unsampled stream, the nodes will be automatically combined into one).

A simple circuit is shown below to illustrate how it works:



Two assay types were measured: % CU, -100 mesh

I. SCM is :

Stream No.	From Unit	To Unit
1	0	1
2	1	2
3	2	0
4	2	1

Unit zero means the stream is connected externally to the circuit.

II. Mass conservation equations generated by the program are:

Unit 1 (Node 1) : 1 4 -2
Unit 2 (Node 2) : 2 -3 -4

Node refers to a unit or equation.

III. Assays balanced and the node status derived by the program are:

	Assay %CU	Balanced -100m	Node Status
Node 1	X	X	N
Node 2	X	X	N

An "X" is marked when an assay is given, otherwise the position is left blank; "N" means the node is a normal node and "NN" means a non-normal node. (As explaned before, a normal node is a node for which all assays must balance; whereas a non-normal node is any node that is not normal.)

However, size distributions cannot be balanced around a ball mill due to size reduction. Therefore node 1 should be a non-normal node. The program misses this point since it can not recognize the process behaviour of the various units or assay types. When an assay is missing, it automatically identifies the connecting node as a non-normal node.

MATBAL allows the user, using the full-screen editor (see figure followed), to:

1. change the node status
2. replace the mass equations
3. change the assays used for balance

The options are sequentially placed on the screen. Prompts such as "WANT TO REPLACE EQUATIONS (Y/N)?" and "WANT TO CHANGE BALANCED ASSAYS (Y/N)?" are on the bottom line of the screen for options 2 and 3 above.

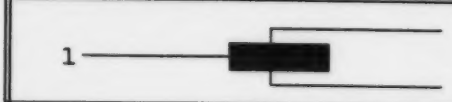
The assays balanced in node 1 in the above example could be changed by the user and as a result, the node status will automatically be changed to "NN" as follows :

	Assay %CU	Balanced -100m	Node Status
Node 1	X		NN
Node 2	X	X	N

The status of the above example is shown on the "Node Status" screen as below:

NODE STATUS

Confirm Node Type: N (Normal Node); NN (Non-normal Node)
[Normal Node]: where all assays satisfy mass conservation eq'n
[Non-normal Node]: where not all assays satisfy



example: Equation 1 -2 -3 (max. 8 streams/unit)

Node	Equation	Assay Balanced 1 2 3 4 5 6 7 8 9 10111213141516	Node Type
1	1 4-2	X	NN
2	2-3-4	X X	N
3			
4			

?:HELP; Esc: Exit; F2:Assay name; Pg/Up/Dn:Page scroll

NOTE:

The user may save the data in a file and later retrieve the file using Option 1 (see section 4.1.2.2). The status will be exactly as shown in the previous figure. However, if Option 2 is used, the program will initiate the automatic flowsheet analysis and both nodes will become nomal nodes.

4.1.2.4 Keyboard action keys

The action keys used in data entry mode are:

? : Help (to activate the keyboard menu listed below)

KEYBOARD MENU

key	function
Arrows	Move Position
Enter	Next Window
Home	First Window
End	Last Window
BS	Backspace and Delete
Del	Delete
Ins	Insert
F1	Delete Current Data
F3	Insert Window
F4	Erase Window
Ctrl ->	Next Column
Ctrl <-	Previous Column
PgDn	Page Down and Continue
ALT F1	ERASE ALL DATA

F2 : Assay name (to display assay types)

ESC : Exit (depending on the following modes)

a) Retrieve/modify mode - exit to data review menu (4.1.2.2) (a faster way to exit current data category and all data modified will be kept)

b) Create mode - exit to main menu (all data created is lost and a warning message will be issued)

PgUp: Scroll to previous page

PgDn: Scroll to next page or continue to next data entry category

4.1.2.5 Default values

Initial or default values are assigned to some variables in case data are not provided by the user:

Variable	Default Value
measured stream	1
measured flowrate	100.00
% rel.std. of above	0.01
assay error model type	5
% rel.std. of all assays	5.00
maximum no. of iterations	99
convergence flowrate tolerance ...	1.0
convergence assay tolerance	1.0
first approximation of flowrates .	*

* calculated by the program

4.2 MATBAL6: Material Balance Calculation and Results Scrolling

The main menu of MATBAL6 is displayed (as below) as soon as MATBAL6 is executed:

```
                    M A T B A L 6

        MATerial BALance of mineral process flowsheets (V.6)

                          1 9 9 0
                       CAMP PROJECT
                       CANMET/EMR
```

TABLE -1- : MENU OPTIONS

F1	Retrieve Data From File
F2	Material Balance Calculation
F3	Save Results in File
F4	View Results By Component
F5	View Final Results By Stream
F6	Print Results By Component
F7	Print Final Results By Stream
F8	Shell To DOS
F9	Quit "MATBAL6"

TABLE 2- MESSAGES

TABLE-3- HELP

ARROWS	: Move Highlight Bar
"F" keys	: Menu Options
ENTER	: Option Selected
ESC	: Return To Table-1

NOTE:

In order to view the results directly on the flowsheet in MATVIE6, the user must make sure the results are saved before leaving MATBAL6. The program will automatically assign the result file names as "fname".ANS, "fname".STS and "fname".OUT (where "fname" is the same file name for the data created and saved in MATEDI6).

4.2.1 Material balance

The theory of material balance and the calculation method are documented in the SPOC manual, Chapter 3.2 (3) and will not be repeated here. The main features are as follows :

1. display of starting time and run time during execution
2. display of menu for printing options
3. display of successive results of each interation
4. display of warning messages and actions recommended
5. option to modify convergence criteria and maximum number of iterations
6. option to scroll the results either grouped by components or by streams
7. option to print the results either by components or streams
8. option to save the results in two files: one grouped by components and the other by streams
9. estimation of flowrates and assays for some unsampled streams

When the material balance computation option is entered (F2 in main menu), the following printing menu(3) is displayed :

MENU FOR RESULT OUTPUTS:

1. Header
2. Condensed input data
3. First approximation of flow rates
4. Assay adjustments and flow rates at each iteration
5. Final results of Material Balance
6. Analysis of calculated adjustments

F1: Help; ESC: Exit data entry; Pg/Up/Dn: Page scroll

Note: **The default option is to print final results only.**

4.2.2 Result interpretation

The output of MATBAL results includes the following information:

1. the observed and calculated flowrates, % recovery (including the flowrates of some unsampled streams)
2. the observed and calculated assays, % recovery and component flowrate (including the assays of some unsampled streams)
3. the statistics of flowrate and assay residuals
4. flowrate sensitivity analysis

4.2.2.1 Recovery and component flowrate

The recovery of a phase in a stream, whose flowrate W_i is calculated, is:

$$\% \text{ Recovery (flowrate)} = \frac{W_i}{W_{ref}} 100\%$$

where W_i is the flowrate of stream i and W_{ref} is the flowrate of the same phase in the reference stream which is chosen by the user (normally, it is the feed stream).

The component flowrate CFR is defined as follows:

$$CFR = \frac{W_i * R_i}{100}$$

where W_i and R_i are respectively the flowrate and assay of stream i. R_i must be in % and CFR is then expressed in the same units as W_i.

The % recovery of a component is:

$$\% \text{ Recovery (assay)} = \frac{CFR_i}{CFR_{ref}}$$

where CFR_i and CFR_{ref} are respectively the component flowrates of stream i and reference stream.

4.2.2.2 Standard residual and outliers

The standard residual RES is defined as:

$$RES = \frac{X_m - X_c}{\sigma}$$

where X_m and X_c are the measured and calculated values and σ the estimated standard deviation of X_m.

This value represents the ratio of the adjustment performed for this particular variable over its standard deviation. A value greater than three is called an **outlier** and should be investigated since it means the adjusted value differs from the measured value by more than three times the standard deviation. The probability of such an occurence is less than 1% in a normal population.

The sum of squares of all assay standard residuals of all components are averaged in each stream as below:

$$\frac{\Sigma\ (RES_i)^2}{N}$$

where RES_i is the standard residual of assay type i and N is the number of assay types in this stream.

The average values calculated above for each stream are listed in the result output. The greater the value means the greater the average adjustment in that stream. This raises suspicion on the sampling error in that particular stream.

Similarly, the average sum of squares of assay residuals per component streams throughout the circuit is also listed, to help identify the analytical error that might have arisen during the analysis procedures.

Standard flowrate residuals are also calculated for measured stream flowrates.

During the interpretation of these statistics, it is important to keep in mind that an average may be inflated simply due to large contributions by few values.

4.2.2.3 Estimation for some unsampled streams

As described in Section 4.1.2.3, when two nodes are connected by an unsampled stream, the nodes will automatically be combined into one and the unsampled stream will be excluded from the adjustment calculation. However, after the material balance has been calculated, the flowrate in some of these unsampled streams can be calculated from the known flowrates of the other streams (based on mass conservation). This is possible when there is only one unknown stream in a node. Similarly, the component flowrate of the unsampled stream can be calculated based on component flowrate conservation and with this flowrate already derived, the assays can be calculated also.

The values calculated for the unsampled streams are shown in the result outputs.

4.2.2.4 Flowrate sensitivity

The Monte Carlo error estimator uses the calculated values of assays as the true values to simulate artificial experimental data belonging to the same population. After each simulation, a material balance is performed to calculate flowrates. At the end of the simulations, the program prints the mean flowrates obtained for all streams, the initial best estimates of all flowrates and their standard deviations around the means in absolute and relative percent values.

4.3 MATVIE6: Results Viewing From The Flowsheet

The main menu of MATVIE6 is displayed (as below) as soon as MATVIE6 is executed:

```
                    M A T V I E 6

        Results for MATBAL6 presented on flowsheet

                        1 9 9 0
                    CAMP PROJECT
                    CANMET/EMR
```

```
TABLE -1- : MENU OPTIONS

F1  Retrieve Data From File
F2  View Results on Flowsheet
F3  Shell to DOS
F4  Quit "MATVIE6"
```

```
TABLE 2- MESSAGES
```

```
TABLE-3- HELP
ARROWS   : Move Highlight Bar
"F" keys: Menu Options
ENTER    : Option Selected
ESC      : Return To Table-1
```

NOTE:

1. In order to view the results directly on the flowsheet, the user must first run MATBAL6 and save the results. The program will automatically assign the file names as "fname".ANS, "fname".STS and "fname".OUT (where "fname" is the file name for the data created and saved in MATEDI6).

2. The results around a specific unit or stream may be viewed by moving the cursor to the desired unit or stream and pressing "O". For locations other than the units or streams, the results of macroscopic stream flowrates will be displayed.

3. The file retrieved in option F1 must be the one used for saving i.e. MATEDI6 data and <u>not</u> the one used for storing results for MATBAL6.

4. Although the flowsheet drawing board is also available in MATVIE6, it is only for results display only and should not be used for flowsheet creation purpose.

4.4 Shell To DOS

This option in the main menu allows the user to "shell" to DOS environment to execute DOS commands. To return to the MATBAL program, simply type "EXIT". Note that the MATBAL program is still memory resident and the full memory will be unavailable.

4.5 Glossary

Normal nodes	-	a unit across which all available assays satisfy mass conservation equations
Non-normal nodes	-	a unit across which some assays do not satisfy mass conservation equations (e.g. size distributions in a ball mill)
Special assays	-	assays across a non-normal node that satisfy mass conservation equations (e.g. percent copper in a ball mill)
Fixed assays	-	assays that the user wishes to treat as constants
SCM	-	stream connection matrix which lists the origin and destination units of each stream
Monte Carlo Simulations	-	simulates random data belonging to a given population (uncorrelated, normally distributed and with the same standard deviation)

5. PROGRAM CAPABILITIES

The maximum dimensions of the variables and limitations of some program features are restricted to the followings due to the DOS addressable memory of 640k :

	Size
Streams	40
Assay types	16
Units (normal node)	25
(non-normal node)	25
(normal + non-normal)	36
No. of streams per mass equation	8
Monte Carlo simulations	50
Measured flow rates	20
Special assays	40
Fixed assays	48
Scrolling pages for final results	64

Note :

These parameter dimensions are interrelated and must meet the following criterion :

(no. of streams) + (normal nodes)*(assay types + 1) + (non-normal nodes) + (special assays) + (2*measured flow rates)

Must be less than or equal to 310

6. MAINTENANCE AND UPDATES

CANMET does not provide any formal maintenance of the programs but would appreciate receiving comments on modifications that could substantially improve the overall program performance.

7. ACKNOWLEDGEMENTS

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APPENDIX A: SAMPLE RUN

A sample run is stored in the file called MATBAL.DAT supplied with the program. The flowsheet (drawn with MATBAL flowsheet drawing option in 10 mins.) is displayed in figure A1 in which data have been collected as described in Table A1. Five assays are available on most streams except stream 12, for which 4 assays are known, as well as for streams 2,4,8,15 and 20 for which no assays are available.

The corresponding stream connection matrix (SCM) and mass equations, both automatically derived by the program, are respectively shown in figures A2 and A3. Due to the unsampled streams, some nodes have been automatically combined and the total number of nodes has been reduced from 12 to 7. As a first approximation, all assays are assumed to have a relative standard deviation of 5% of the measured value. Two flowrates are measured for streams 1 and 17, with a relative standard deviation of 5%.

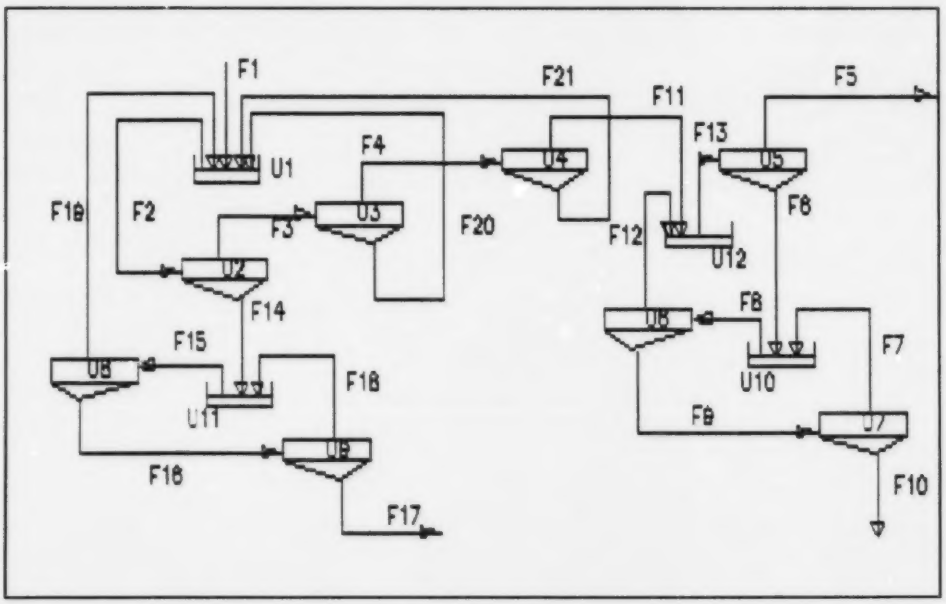

Fig. A1: Sample run flowsheet drawn by user on the computer screen

To illustrate all features of MATBAL in one sample run, the following assumptions are also made: assays 3 and 4 in stream 1 are not to be adjusted, and the sensitivity of the calculated flowrates is required. The material balance calculation, including 10 complete Monte Carlo simulations for sensitivity analysis, was completed in 97 seconds on a Compaq 386 computer.

TABLE A1 Input Data and Program Options Used in Sample Run

No.	Assay 1	Assay 2	Assay 3	Assay 4	Assay 5
1	.0640	.3500	2.1900	2.7000	13.9000
2					
3	.0580	.2600	.3500	2.7000	14.7000
4					
5	.0240	.1300	.1200	.1900	14.8000
6	.2260	1.4600	1.5800	33.3000	12.4000
7	.3320	1.2800	2.1300	5.6000	29.7000
8					
9	.3240	1.7200	2.0100	37.0000	13.7000
10	.2020	1.7800	1.5400	46.2000	6.8000
11	.0340	.1900	.1900	2.6000	14.4000
12		.8800	.8900	3.0000	26.4000
13	.0360	.2000	.2000	2.6100	14.8000
14	.6150	2.1600	18.0400	5.5000	11.8000
15					
16	1.0280	2.9200	25.0200	4.4000	7.5000
17	.4600	2.3900	28.4100	4.2000	4.1000
18	.7360	2.9900	12.0300	9.7000	17.2000
19	.5950	1.8000	4.3500	7.4000	21.9000
20					
21	1.5420	2.7500	8.4500	11.1000	20.8000

Note: All assays have 5% rel.std.dev.
Fixed assays: assay 3 and 4 in stream 1
Measured flow rate: stream 17 at 6.35 t/h,
measured feed: 100 t/h
No assays in streams: 2, 4, 8, 15 and 20
2 non-normal nodes and 5 normal nodes
10 Monte Carlo simulations for flowrate sensitivity

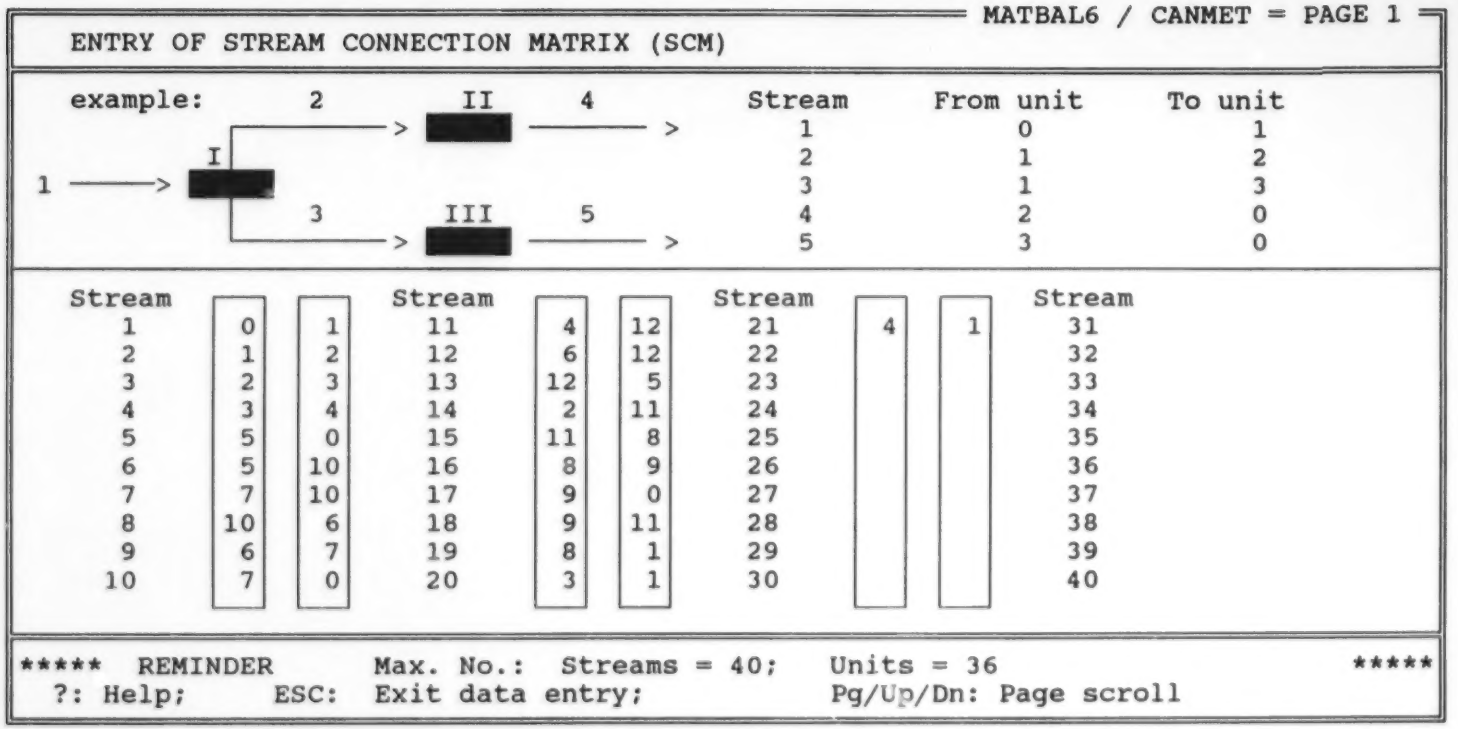

Fig. A2: Stream connection matrix automatically generated from flowsheet drawing

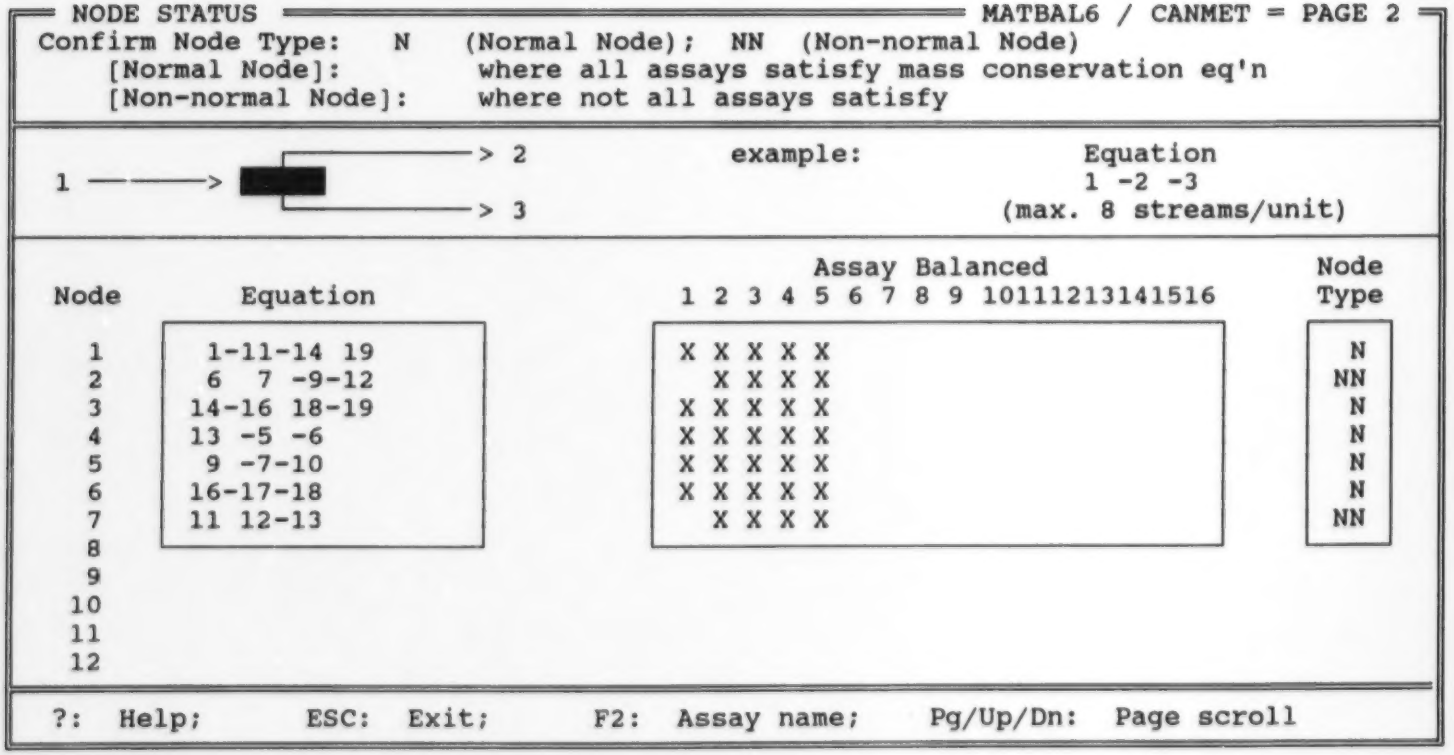
NODE STATUS
MATBAL6 / CANMET = PAGE 2
Confirm Node Type: N (Normal Node); NN (Non-normal Node)
[Normal Node]: where all assays satisfy mass conservation eq'n
[Non-normal Node]: where not all assays satisfy
1
> 2
> 3
example:
Equation
1 -2 -3
(max. 8 streams/unit)
Node
Equation
Assay Balanced
1 2 3 4 5 6 7 8 9 10111213141516
Node Type
1 1-11-14 19 X X X X X N
2 6 7 -9-12 X X X X NN
3 14-16 18-19 X X X X X N
4 13 -5 -6 X X X X X N
5 9 -7-10 X X X X X N
6 16-17-18 X X X X X N
7 11 12-13 X X X X NN
8
9
10
11
12
?: Help; ESC: Exit; F2: Assay name; Pg/Up/Dn: Page scroll

Fig. A3: Equations automatically generated by MATBAL

An on-line display during the execution is shown in figure A4.

```
MONTE CARLO SIMULATION                                    MATBAL6/CANMET

Job title:  Flotation Circuit Balance                      07-01- 1991

Time start:  15:33:11                  Run time:     15:33:18

Iteration     1                        Monte Carlo iteration 2

Calculated Flow Rates

 1  99.9905     5   88.5856     6    6.8934     7    2.0973     9    6.7130
10   4.6158    11   93.2014    12    2.2776    13   95.4790    14   12.5762
16   8.5378    17    6.7892    18    1.7487    19    5.7870

Message: Assay    R(17,1)    adjusted by more than 3 sigma

Proposed
Action:  Check this value or modify its standard deviation
                    (any message will be listed in the result files)

F1: Best estimated flow rates = F2: Change conv. criteria = F9: Quit
```

Fig. A4: On-line display during execution

The final results (grouped by components) are listed below:

***** NOTE FOLLOWING STREAM(S) NOT USED IN MATERIAL BALANCE :
2 3 4 8 15 20 21

****

DATE: 07-01-1991

Flotation Circuit Balance
==========

MATBAL RESULTS AFTER 9 ITERATIONS, CONVERGENCE ACHIEVED
CALCULATED MATERIAL BALANCE

STREAM FLOW-RATES

M	STREAM	OBSERVED	CALCULATED	% RECOVERY
1	FLOAT FEED	100.0000	100.0000	100.0000
5	FINAL TAILS	N-O	88.7078	88.7078
6	ZN RGHR CONC	N-O	6.6920	6.6920
7	ZN CL2 TAIL	N-O	2.1661	2.1661
9	ZN CL1 CONC	N-O	6.7429	6.7429
10	FINAL ZN CONC	N-O	4.5768	4.5768
11	CU SCV TAIL	N-O	93.2846	93.2847
12	ZN CL1 TAIL	N-O	2.1152	2.1152
13	ZN RGHR FEED	N-O	95.3998	95.3998
14	CU RGHR CONC	N-O	12.3722	12.3722
16	CU CL1 CONC	N-O	8.8844	8.8844
17	FINAL CU CONC	6.3500	6.7153	6.7153
18	CU CL2 TAIL	N-O	2.1691	2.1691
19	CU CL1 TAIL	N-O	5.6569	5.6569

STREAM FLOWRATE(S) CALCULATED FROM ABOVE

8	ZN CL1 FEED	N-O	8.8580	8.8580
15	CU CL1 FEED	N-O	14.5413	14.5413

****

COMPONENT ASSAYS BY ANALYSIS

Au(oz/t)

M	STREAM	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
1	FLOAT FEED	.0640	.0667	100.00	.66679E-01
5	FINAL TAILS	.0240	.0234	31.173	.20786E-01
6	ZN RGHR CONC	.2260	.2222	22.300	.14870E-01
7	ZN CL2 TAIL	.3320	.3530	11.468	.76467E-02
9	ZN CL1 CONC	.3240	.2617	26.462	.17644E-01
10	FINAL ZN CONC	.2020	.2184	14.994	.99977E-02

11	CU SCV TAIL	.0340	.0333	46.580	.31059E-01
12	ZN CL1 TAIL	.0000	.0000	.31722E-03	.21152E-06
13	ZN RGHR FEED	.0360	.0374	53.473	.35655E-01
14	CU RGHR CONC	.6150	.5690	105.57	.70393E-01
16	CU CL1 CONC	1.0280	.5939	79.127	.52761E-01
17	FINAL CU CONC	.4600	.5304	53.420	.35620E-01
18	CU CL2 TAIL	.7360	.7903	25.707	.17141E-01
19	CU CL1 TAIL	.5950	.6147	52.150	.34773E-01
ESTIMATED VALUES FOR STREAM(S) NOT USED IN MATERIAL BALANCE					
8	ZN CL1 FEED	N-O	.2542	33.768	.22516E-01
15	CU CL1 FEED	N-O	.6020	131.28	.87534E-01

Ag(oz/t)

M	STREAM	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
1	FLOAT FEED	.3500	.3543	100.00	.35434
5	FINAL TAILS	.1300	.1196	29.929	.10605
6	ZN RGHR CONC	1.4600	1.4724	27.807	.98531E-01
7	ZN CL2 TAIL	1.2800	1.3004	7.9494	.28168E-01
9	ZN CL1 CONC	1.7200	1.6054	30.549	.10825
10	FINAL ZN CONC	1.7800	1.7497	22.600	.80079E-01
11	CU SCV TAIL	.1900	.1995	52.529	.18613
12	ZN CL1 TAIL	.8800	.8724	5.2075	.18452E-01
13	ZN RGHR FEED	.2000	.2144	57.737	.20458
14	CU RGHR CONC	2.1600	2.1797	76.107	.26968
16	CU CL1 CONC	2.9200	2.6407	66.211	.23461
17	FINAL CU CONC	2.3900	2.5048	47.471	.16821
18	CU CL2 TAIL	2.9900	3.0614	18.741	.66405E-01
19	CU CL1 TAIL	1.8000	1.7937	28.637	.10147
ESTIMATED VALUES FOR STREAM(S) NOT USED IN MATERIAL BALANCE					
8	ZN CL1 FEED	N-O	1.4303	35.757	.12670
15	CU CL1 FEED	N-O	2.3112	94.848	.33608

%Cu

M	STREAM	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
1	FLOAT FEED	2.1900	2.1900	100.00	2.1900
5	FINAL TAILS	.1200	.1165	4.7194	.10335
6	ZN RGHR CONC	1.5800	1.4304	4.3709	.95722E-01
7	ZN CL2 TAIL	2.1300	2.1910	2.1671	.47460E-01
9	ZN CL1 CONC	2.0100	1.8408	5.6676	.12412
10	FINAL ZN CONC	1.5400	1.6750	3.5005	.76660E-01
11	CU SCV TAIL	.1900	.1930	8.2198	.18001
12	ZN CL1 TAIL	.8900	.9012	.87040	.19062E-01
13	ZN RGHR FEED	.2000	.2087	9.0902	.19908
14	CU RGHR CONC	18.0400	18.2325	103.00	2.2558
16	CU CL1 CONC	25.0200	25.5534	103.67	2.2703
17	FINAL CU CONC	28.4100	29.9312	91.780	2.0100
18	CU CL2 TAIL	12.0300	11.9999	11.885	.26029
19	CU CL1 TAIL	4.3500	4.3449	11.223	.24579

ESTIMATED VALUES FOR STREAM(S) NOT USED IN MATERIAL BALANCE

8	ZN CL1 FEED	N-O	1.6164	6.5380	.14318
15	CU CL1 FEED	N-O	17.3028	114.89	2.5161

%Zn

M	STREAM	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
1	FLOAT FEED	2.7000	2.7000	100.00	2.7000
5	FINAL TAILS	.1900	.1913	6.2864	.16973
6	ZN RGHR CONC	33.3000	34.9310	86.577	2.3376
7	ZN CL2 TAIL	5.6000	5.6108	4.5013	.12154
9	ZN CL1 CONC	37.0000	35.5301	88.732	2.3958
10	FINAL ZN CONC	46.2000	49.6902	84.230	2.2742
11	CU SCV TAIL	2.6000	2.6199	90.517	2.4439
12	ZN CL1 TAIL	3.0000	2.9953	2.3465	.63355E-01
13	ZN RGHR FEED	2.6100	2.6282	92.863	2.5073
14	CU RGHR CONC	5.5000	5.4659	25.047	.67626
16	CU CL1 CONC	4.4000	5.0595	16.648	.44951
17	FINAL CU CONC	4.2000	3.8130	9.4834	.25605
18	CU CL2 TAIL	9.7000	8.9186	7.1649	.19345
19	CU CL1 TAIL	7.4000	7.4282	15.563	.42020

ESTIMATED VALUES FOR STREAM(S) NOT USED IN MATERIAL BALANCE

8	ZN CL1 FEED	N-O	27.7613	91.078	2.4591
15	CU CL1 FEED	N-O	5.9810	32.212	.86971

%Fe

M	STREAM	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
1	FLOAT FEED	13.9000	13.7851	100.00	13.785
5	FINAL TAILS	14.8000	14.8774	95.737	13.197
6	ZN RGHR CONC	13.4000	13.1093	6.3639	.87727
7	ZN CL2 TAIL	29.7000	29.2356	4.5939	.63327
9	ZN CL1 CONC	13.7000	14.0076	6.8517	.94452
10	FINAL ZN CONC	6.8000	6.8006	2.2579	.31125
11	CU SCV TAIL	14.4000	14.4811	97.995	13.509
12	ZN CL1 TAIL	26.4000	26.7599	4.1060	.56602
13	ZN RGHR FEED	14.8000	14.7534	102.10	14.075
14	CU RGHR CONC	11.8000	12.0601	10.824	1.4921
16	CU CL1 CONC	7.5000	7.3557	4.7407	.65352
17	FINAL CU CONC	4.1000	4.1162	2.0052	.27642
18	CU CL2 TAIL	17.2000	17.3850	2.7355	.37710
19	CU CL1 TAIL	21.9000	21.4904	8.8188	1.2157

ESTIMATED VALUES FOR STREAM(S) NOT USED IN MATERIAL BALANCE

8	ZN CL1 FEED	N-O	17.0527	10.958	1.5105
15	CU CL1 FEED	N-O	12.8544	13.560	1.8692

****

WARNING :ASSAY R(9, 1) ADJUSTED BY MORE THAN 3 SIGMA
WARNING :ASSAY R(16, 1) ADJUSTED BY MORE THAN 3 SIGMA
WARNING :ASSAY R(17, 1) ADJUSTED BY MORE THAN 3 SIGMA

```
MONTE-CARLO ITERATION            1
MONTE-CARLO ITERATION            2
MONTE-CARLO ITERATION            3
MONTE-CARLO ITERATION            4
MONTE-CARLO ITERATION            5
MONTE-CARLO ITERATION            6
MONTE-CARLO ITERATION            7
MONTE-CARLO ITERATION            8
MONTE-CARLO ITERATION            9
MONTE-CARLO ITERATION           10
*******************************************************************************
ERROR ESTIMATES FOR CALCULATED FLOW RATES
MONTE CARLO SIMULATION METHOD WITH  10 REPEATS


Flotation Circuit Balance
=========================

STATISTICAL TEST ON CALCULATED FLOW RATES
-------------------------------------------------------------------------------
```

M	MEAN OF 10 FLOW RATES	FLOW RATE (BEST ESTIMATE)	SIGMA (ABSOLUTE)	SIGMA (PERCENT)
1	99.9981	100.0000	.0074	.0074
5	88.6892	88.7078	.1267	.1429
6	6.8572	6.6920	.3929	5.8709
7	2.0213	2.1661	.2150	9.9274
9	6.6169	6.7429	.1967	2.9167
10	4.5957	4.5768	.0797	1.7425
11	93.2849	93.2846	.0998	.1070
12	2.2615	2.1152	.3425	16.1915
13	95.5464	95.3998	.3847	.4032
14	12.2786	12.3722	.4505	3.6412
16	8.8747	8.8844	.3607	4.0596
17	6.7132	6.7153	.0986	1.4684
18	2.1615	2.1691	.3026	13.9507
19	5.5654	5.6569	.4473	7.9069

```
     -----  END OF MATBAL6  -----
```

The final results (grouped by streams) are listed below:

****

DATE: 07-01-1991

Flotation Circuit Balance
==========

MATBAL RESULTS AFTER 9 ITERATIONS, CONVERGENCE ACHIEVED
CALCULATED MATERIAL BALANCE

STREAM FLOW-RATES

M	STREAM	OBSERVED	CALCULATED	% RECOVERY
1	FLOAT FEED	100.0000	100.0000	100.0000
5	FINAL TAILS	N-O	88.7078	88.7078
6	ZN RGHR CONC	N-O	6.6920	6.6920
7	ZN CL2 TAIL	N-O	2.1661	2.1661
9	ZN CL1 CONC	N-O	6.7429	6.7429
10	FINAL ZN CONC	N-O	4.5768	4.5768
11	CU SCV TAIL	N-O	93.2846	93.2847
12	ZN CL1 TAIL	N-O	2.1152	2.1152
13	ZN RGHR FEED	N-O	95.3998	95.3998
14	CU RGHR CONC	N-O	12.3722	12.3722
16	CU CL1 CONC	N-O	8.8844	8.8844
17	FINAL CU CONC	6.3500	6.7153	6.7153
18	CU CL2 TAIL	N-O	2.1691	2.1691
19	CU CL1 TAIL	N-O	5.6569	5.6569
	STREAM FLOWRATE(S) CALCULATED FROM ABOVE			
8	ZN CL1 FEED	N-O	8.8580	8.8580
15	CU CL1 FEED	N-O	14.5413	14.5413

****

COMPONENT ASSAYS BY STREAM

STREAM 1 FLOAT FEED

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.0640	.0667	100.00	.66679E-01
Ag(oz/t)	.3500	.3543	100.00	.35434
%Cu	2.1900	2.1900	100.00	2.1900
%Zn	2.7000	2.7000	100.00	2.7000
%Fe	13.9000	13.7851	100.00	13.785
FLOWRATE	100.000	100.000	100.000	

STREAM 5 FINAL TAILS

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.0240	.0234	31.173	.20786E-01
Ag(oz/t)	.1300	.1196	29.929	.10605
%Cu	.1200	.1165	4.7194	.10335
%Zn	.1900	.1913	6.2864	.16973
%Fe	14.8000	14.8774	95.737	13.197
FLOWRATE	N-O	88.708	88.708	

STREAM 6 ZN RGHR CONC

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.2260	.2222	22.300	.14870E-01
Ag(oz/t)	1.4600	1.4724	27.807	.98531E-01
%Cu	1.5800	1.4304	4.3709	.95722E-01
%Zn	33.3000	34.9310	86.577	2.3376
%Fe	13.4000	13.1093	6.3639	.87727
FLOWRATE	N-O	6.692	6.692	

STREAM 7 ZN CL2 TAIL

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.3320	.3530	11.468	.76467E-02
Ag(oz/t)	1.2800	1.3004	7.9494	.28168E-01
%Cu	2.1300	2.1910	2.1671	.47460E-01
%Zn	5.6000	5.6108	4.5013	.12154
%Fe	29.7000	29.2356	4.5939	.63327
FLOWRATE	N-O	2.166	2.166	

STREAM 9 ZN CL1 CONC

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.3240	.2617	26.462	.17644E-01
Ag(oz/t)	1.7200	1.6054	30.549	.10825
%Cu	2.0100	1.8408	5.6676	.12412
%Zn	37.0000	35.5301	88.732	2.3958
%Fe	13.7000	14.0076	6.8517	.94452
FLOWRATE	N-O	6.743	6.743	

STREAM 10 FINAL ZN CONC

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.2020	.2184	14.994	.99977E-02
Ag(oz/t)	1.7800	1.7497	22.600	.80079E-01
%Cu	1.5400	1.6750	3.5005	.76660E-01
%Zn	46.2000	49.6902	84.230	2.2742
%Fe	6.8000	6.8006	2.2579	.31125
FLOWRATE	N-O	4.577	4.577	

STREAM 11 CU SCV TAIL

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.0340	.0333	46.580	.31059E-01
Ag(oz/t)	.1900	.1995	52.529	.18613
%Cu	.1900	.1930	8.2198	.18001
%Zn	2.6000	2.6199	90.517	2.4439
%Fe	14.4000	14.4811	97.995	13.509
FLOWRATE	N-O	93.285	93.285	

STREAM 12 ZN CL1 TAIL

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.0000	.0000	.31722E-03	.21152E-06
Ag(oz/t)	.8800	.8724	5.2075	.18452E-01
%Cu	.8900	.9012	.87040	.19062E-01
%Zn	3.0000	2.9953	2.3465	.63355E-01
%Fe	26.4000	26.7599	4.1060	.56602
FLOWRATE	N-O	2.115	2.115	

STREAM 13 ZN RGHR FEED

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.0360	.0374	53.473	.35655E-01
Ag(oz/t)	.2000	.2144	57.737	.20458
%Cu	.2000	.2087	9.0902	.19908
%Zn	2.6100	2.6282	92.863	2.5073
%Fe	14.8000	14.7534	102.10	14.075
FLOWRATE	N-O	95.400	95.400	

STREAM 14 CU RGHR CONC

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.6150	.5690	105.57	.70393E-01
Ag(oz/t)	2.1600	2.1797	76.107	.26968
%Cu	18.0400	18.2325	103.00	2.2558
%Zn	5.5000	5.4659	25.047	.67626
%Fe	11.8000	12.0601	10.824	1.4921
FLOWRATE	N-O	12.372	12.372	

STREAM 16 CU CL1 CONC

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	1.0280	.5939	79.127	.52761E-01
Ag(oz/t)	2.9200	2.6407	66.211	.23461
%Cu	25.0200	25.5534	103.67	2.2703
%Zn	4.4000	5.0595	16.648	.44951
%Fe	7.5000	7.3557	4.7407	.65352
FLOWRATE	N-O	8.884	8.884	

STREAM 17 FINAL CU CONC

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.4600	.5304	53.420	.35620E-01
Ag(oz/t)	2.3900	2.5048	47.471	.16821
%Cu	28.4100	29.9312	91.780	2.0100
%Zn	4.2000	3.8130	9.4834	.25605
%Fe	4.1000	4.1162	2.0052	.27642
FLOWRATE	6.350	6.715	6.715	

STREAM 18 CU CL2 TAIL

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.7360	.7903	25.707	.17141E-01
Ag(oz/t)	2.9900	3.0614	18.741	.66405E-01
%Cu	12.0300	11.9999	11.885	.26029
%Zn	9.7000	8.9186	7.1649	.19345
%Fe	17.2000	17.3850	2.7355	.37710
FLOWRATE	N-O	2.169	2.169	

STREAM 19 CU CL1 TAIL

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	.5950	.6147	52.150	.34773E-01
Ag(oz/t)	1.8000	1.7937	28.637	.10147
%Cu	4.3500	4.3449	11.223	.24579
%Zn	7.4000	7.4282	15.563	.42020
%Fe	21.9000	21.4904	8.8188	1.2157
FLOWRATE	N-O	5.657	5.657	

ESTIMATED ASSAYS FOR STREAMS NOT USED IN MATERIAL BALANCE

STREAM 8 ZN CL1 FEED

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	N-O	.2542	33.768	.22516E-01
Ag(oz/t)	N-O	1.4303	35.757	.12670
%Cu	N-O	1.6164	6.5380	.14318
%Zn	N-O	27.7613	91.078	2.4591
%Fe	N-O	17.0527	10.958	1.5105
FLOWRATE	N-O	8.358	8.858	

STREAM 15 CU CL1 FEED

ASSAY	OBSERVED	CALCULATED	%RECOVERY	COMPONENT FLOW RATE
Au(oz/t)	N-O	.6020	131.28	.87534E-01
Ag(oz/t)	N-O	2.3112	94.848	.33608
%Cu	N-O	17.3028	114.89	2.5161
%Zn	N-O	5.9810	32.212	.86971
%Fe	N-O	12.8544	13.560	1.8692
FLOWRATE	N-O	14.541	14.541	

****
WARNING :ASSAY R(9, 1) ADJUSTED BY MORE THAN 3 SIGMA
WARNING :ASSAY R(16, 1) ADJUSTED BY MORE THAN 3 SIGMA
WARNING :ASSAY R(17, 1) ADJUSTED BY MORE THAN 3 SIGMA

----- END OF MATBAL6 -----

APPENDIX B

DRIVER FOR OTHER TYPES OF PLOTTER

An example of the driver, that shows how instructions for EPSON HI-80 have been modified for HP-7475A, is given in the file HPPLOT.FOR written in FORTRAN language.

To write one's own driver the user can start from the program HPPLOT.FOR. The program is compiled with the following commands:

```
FL /FPi /c /Od HPPLOT.FOR
LINK HPPLOT+LPRINT,,,"LIBRARY NAME"
```

The driver can be written in other languages and compiled accordingly. "LIBRARY NAME" is the name of the library used in the link command, e.g. LLIBFORE for FORTRAN library.

The driver consists of the following procedures:

a) read instructions written for EPSON HI-80 plotter from file PLOTTER.DAT
b) scale parameter values
c) redifine EPSON HI-80 commands for the plotter selected
d) send instructions to the plotter

The name of the executable driver as well as the communication parameters (serial or parallel, baud rate, parity etc.) are to be specified by the user on the third and fourth of the display screens when executing the INSTALL program.

a) STEP # 1 : READ INSTRUCTIONS

The file PLOTTER.DAT contains EPSON HI-80 commands as shown in figure B1. The left window shows the structure of the commands and the right window shows an example.

The format used in file PLOTTER.DAT is as follows : 2 spaces for the command code, 5 spaces for parameter #1, 4 spaces for parameter #2 and #3, 5 spaces for parameter #4 and #5. Commas are used to separate parameter values.

PLOTTER.DAT : EPSON HI-80 INSTRUCTIONS	
IN	IN
SPn	SP3
MAx,y	MA 1000, 500
DAx,y	DA 1000,1000
SIh,w	SI .57, .19
LAxxxxxxx	LATEST
CAxc,yc,r,as,ae	CA 1000,1000, 500, 900, 270

Fig. B1: File PLOTTER.DAT

Figure B2 provides a description for the HI-80 commands.

CODE	DESCRIPTION
SP	FUNCTION : SELECTS A PEN FORMAT : SPn PARAMETERS : N--> PEN NUMBER
IN	FUNCTION : INITIALIZATION FORMAT : IN PARAMETERS : NO PARAMETERS
MA	FUNCTION : LIFT THE PEN AND MOVE IT TO AN ABSOLUTE LOCATION DEFINED BY THE COORDINATES X,Y FORMAT : MAx,y PARAMETERS : x,y ---> POINT COORDINATES
DA	FUNCTION : DRAW A LINE FROM THE CURRENT PEN POSITION TO AN ABSOLUTE LOCATION DEFINED BY THE COORDINATES X,Y FORMAT : DAx,y PARAMETERS : X,Y ---> POINT COORDINATES
SI	FUNCTION : SPECIFY THE HEIGHT AND WIDTH OF THE CHARACTERS PLOTTED WITH "LA" COMMAND FORMAT : SIh,w PARAMETERS : h ---> HEIGHT (UNITS=1/10 MILLIMETERS) w ---> WIDTH (UNITS=1/10 MILLIMETERS)
LA	FUNCTION : DRAW CHARACTER STRING AT CURSOR POSITION FORMAT : LAxxxxxxx PARAMETERS : xxxxxxx ---> CHARACTER STRING
CA	FUNCTION : DRAW A CRICLE OR AN ARC WITH CENTER AT THE ABSOLUTE POSITION DEFINED BY THE COORDINATES xc,yc FORMAT : CAxc,yc,r,as,ae PARAMETERS : xc,yc ---> CENTER COORDINATES r ---> RADIUS as ---> STARTING ANGLE (UNITS-0.1 DEGREE) ae ---> ENDING ANGLE (UNITS-0.1 DEGREE)

Fig. B2: List of EPSON HI-80 commands

b) STEP # 2 : SCALE PARAMETERS

Three measurement units (i.e. point coordinates, height/width and angles) used by a plotter are to be converted.

For HP-7475A, the scaling parameters are calculated as follows:

1. Point coordinates

   The scaling parameter is equal to the ratio of the maximum plotting range on HP-7475A over the maximum plotting range on EPSON HI-80.

   For X axis, K=10365/2578 = 4.02
   For Y axis, K=7962/1981 = 4.01

   A value of 4 is used.

2. Height and width

   The height and width of a character are measured in 0.1 mm for EPSON HI-80, but in centimeters for HP-7475A. A value of 1/100 is used for the factor HL.

3. Angles

   The angles are given in 0.1 degree for EPSON HI-80, but in degrees for HP-7475A. A value of 1/10 is used for the factor HA.

Figure B3 shows a summary of the equations used for conversion, as well as an example of the scaling values used in the file PLOTTER.DAT.

SCALING PARAMETERS	
x=x*K+X0 y=y*K+Y0 r=r*K h=h/HL w=w/HL as=as/HA ae=ae/HA	K=4, X0=0, Y0=400, HL=100, HA=10 IN SP3 MA 4000,2400 DA 4000,4400 SI .57, .19 LATEST CA 4000,4400, 500, 90, 270

Fig. B3: Scaling parameters

C) STEP # 3 : REDEFINE COMMANDS FOR OTHER PLOTTERS

All commands in figure 4 have to be redefined for other types of plotters. The syntax of the commands for the plotter to be selected must be considered. Figure B4 shows the equivalent commands that are used in EPSON HI-80 and HP-7475A. Three arc drawing commands (i.e. PA,PA,AA) are required in HP-7475A instead of one command (i.e. CA) in EPSON HI-80.

REDEFINE DATA FOR HP 7475A PLOTTER		
EPSON HI-80		HP-7475A
IN	----->	IN;
SPn	----->	SPn;
MAx,y	----->	PA,PU,x,y;
DAx,y	----->	PA,PD,x,y;
SIh,w	----->	SI,h,w;
LAxxxx	----->	LBxxxxx;
CAxc,yc,r,as,ae	----->	PA,PU,xs,ys; PA,PD,xs,ys; AA,xc,yc,a,c;

Fig. B4: Commands used in EPSON HI-80 and HP 7475A

D) STEP # 4 : SEND INSTRUCTIONS TO THE PLOTTER

Figure B5 shows the commands that have been redefined for plotter HP-7475A. The next step will be sending them to the plotter. Special attention must be given to the terminator instruction. For HP-7475A the terminator instruction is ';' (make sure ';' is not followed by a <Return> or <Line feed> character). In the file HPPLOT.FOR, Subroutine PRTHP is used to send instructions to the plotter. If a <Return> or other code is required by your plotter, this subroutine must be modified to include this code at the end of the command.

IN;	IN;
SPn;	SP3;
PA,PU,x,y;	PA,PU,4000,2400;
PA,PD,x,y;	PA,PD,4000,4400;
SI,h,w;	SI,.19,.57;
LBxxxxxx;	LBTEST;
PA,PU,xs,ys;	PA,PU,4000,4400;
PA,PD,xs,ys;	PA,PD,4000,4400;
AA,xc,yc,a,c;	AA,4000,4400,180,5;

Fig. B5: HP 7475A commands